National Center for Asphalt Technology
NCAT
AUBURN UNIVERSITY

Construction Issues

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Construction Issues

- From Loading of Produced Mix Through Compaction
- Two Primary Causes of Increased Potential for Moisture Damage
  - Segregation
  - Low Density

Loading of Mixture

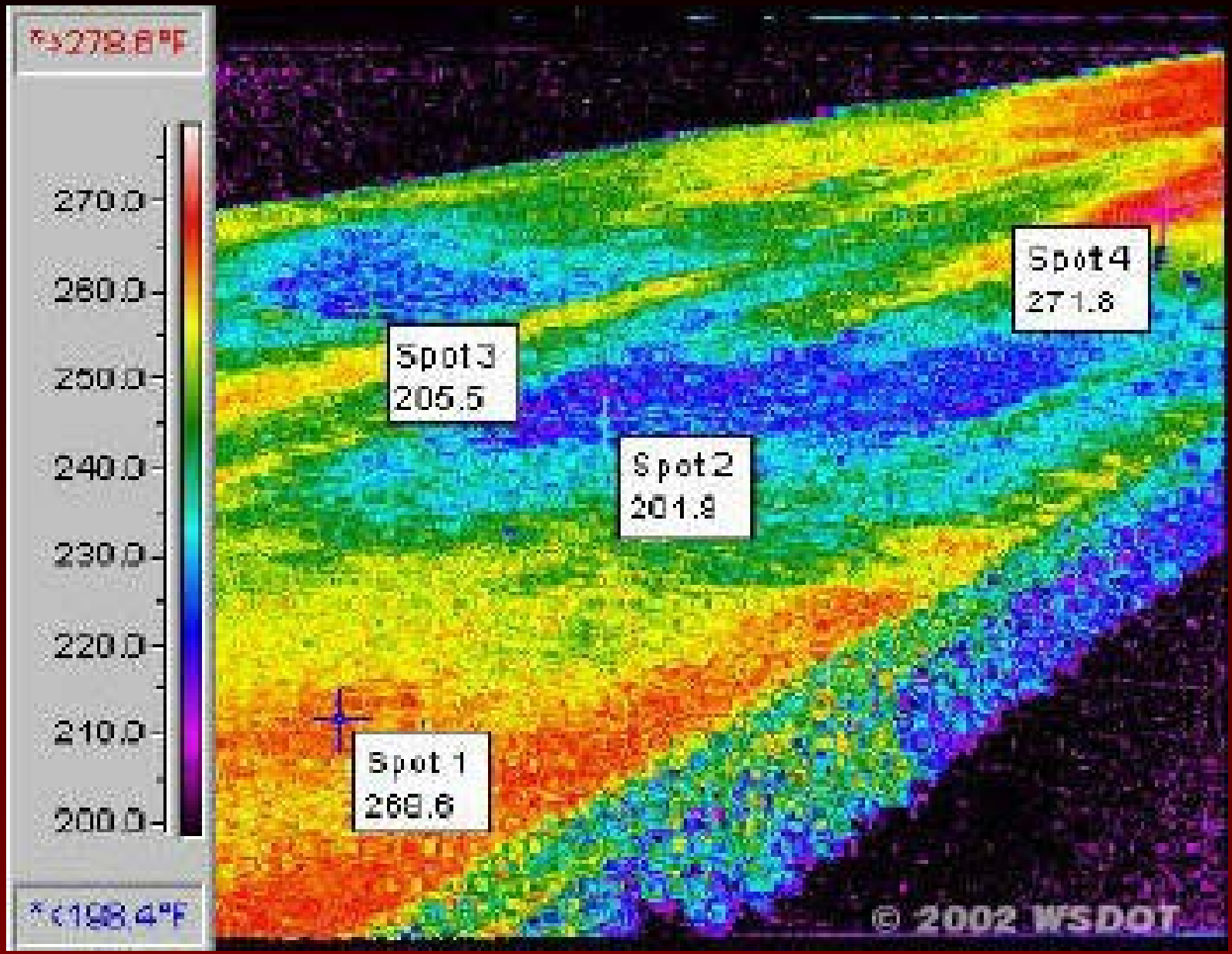
- Minimize Segregation

Transportation of Mixture

- Improperly Loaded Mixes Segregate
- Draindown (Coarse-Graded Mixes)
- Thermal Segregation
  - Insulated Trucks
  - Tarps

Charging of Paver

- Break the Mix
- Flood Hopper
- Material Transfer Vehicle
  - Remix
  - Minimize Physical and Thermal Segregation


>278.8°F
270.0
260.0
250.0
240.0
230.0
220.0
210.0
200.0
<198.4°F
Spot4
271.8
Spot3
205.5
Spot2
201.9
Spot 1
268.6
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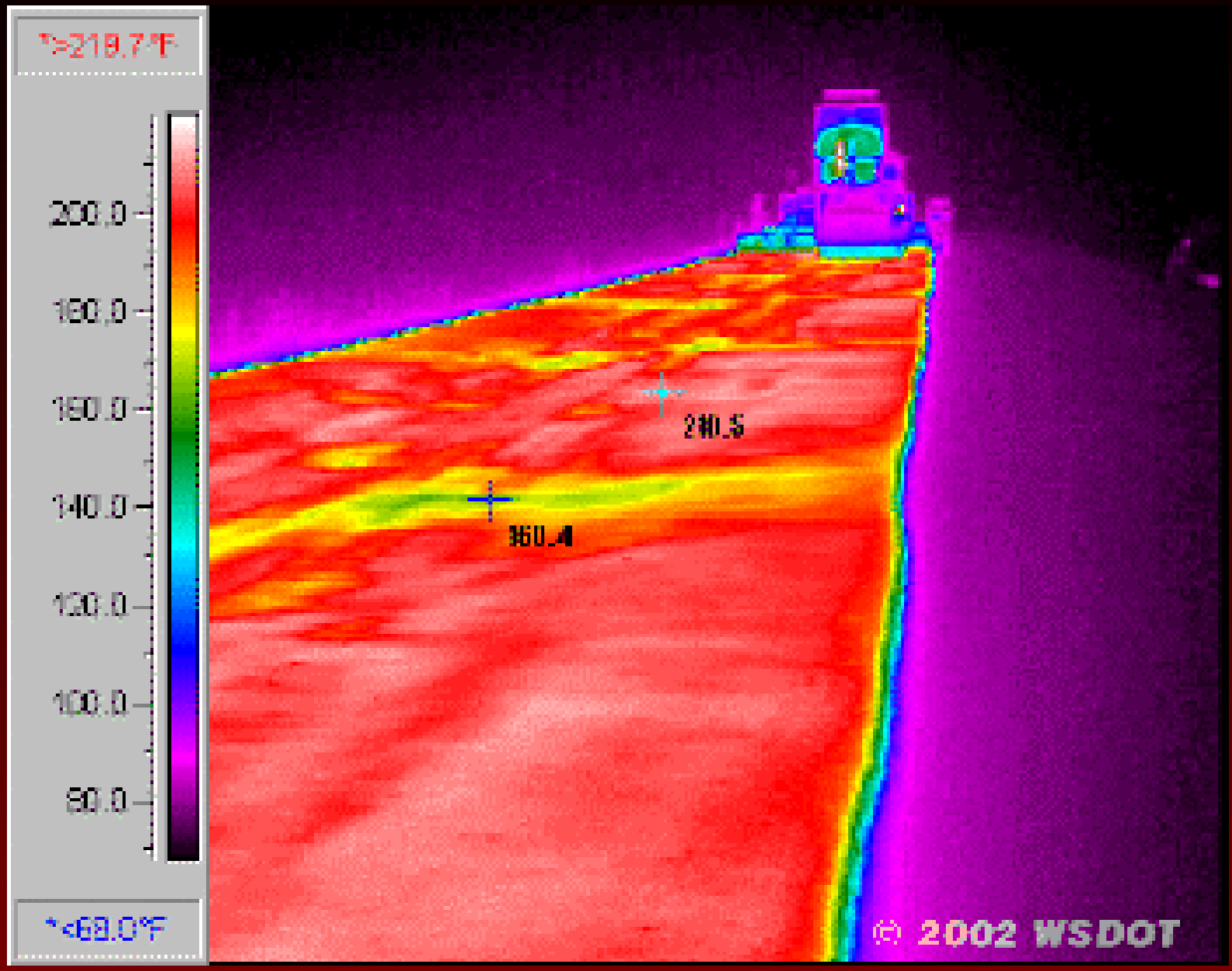
°>219.7°F
200.0
180.0
160.0
140.0
120.0
100.0
80.0
°<68.0°F
240.5
360.4
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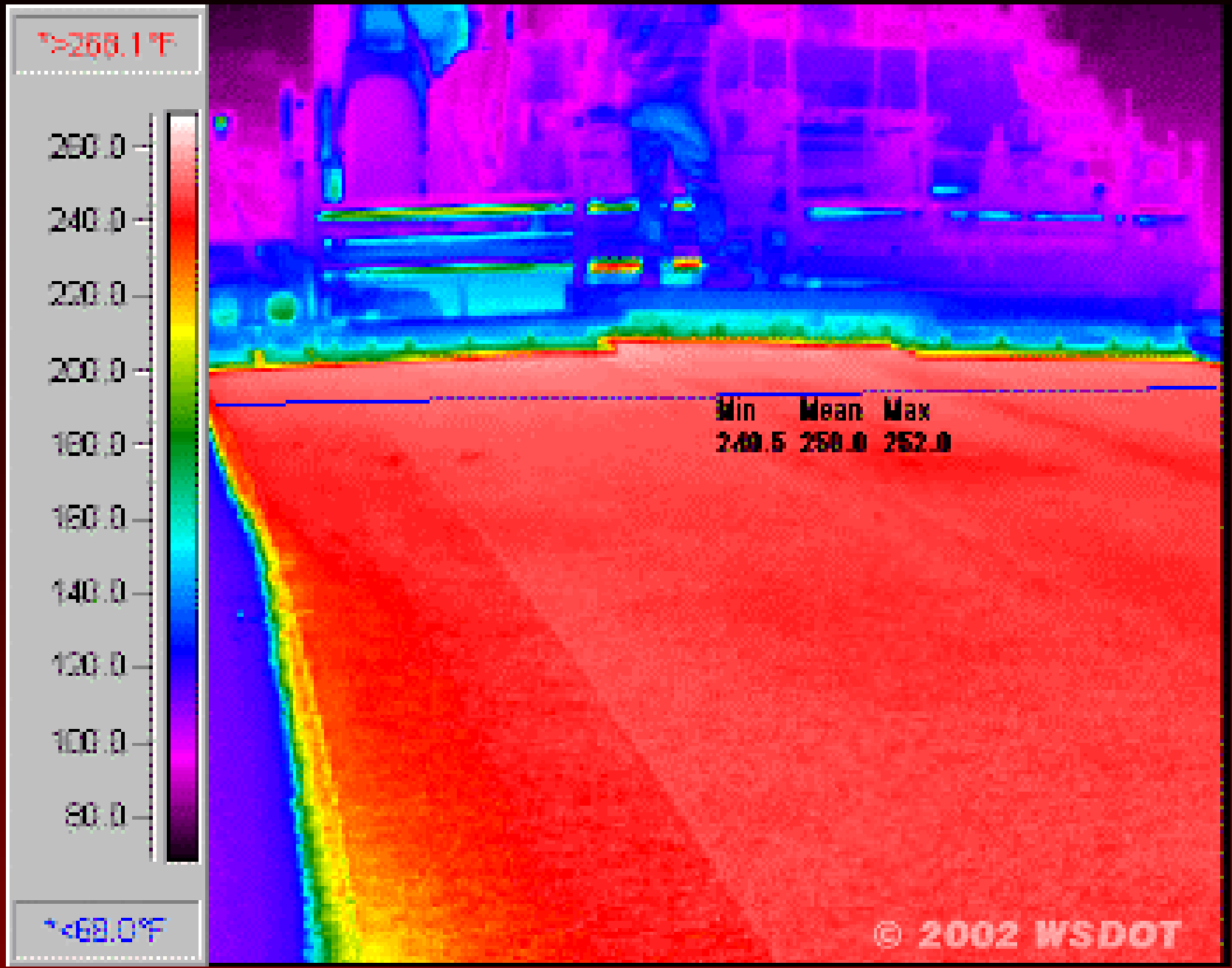
°>266.1°F
260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
100.0
80.0
°<68.0°F
Min Mean Max
249.5 258.0 262.0
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Compaction

- Achieve Proper Density
  - Permeability
- Minimize Fracture of Aggregate


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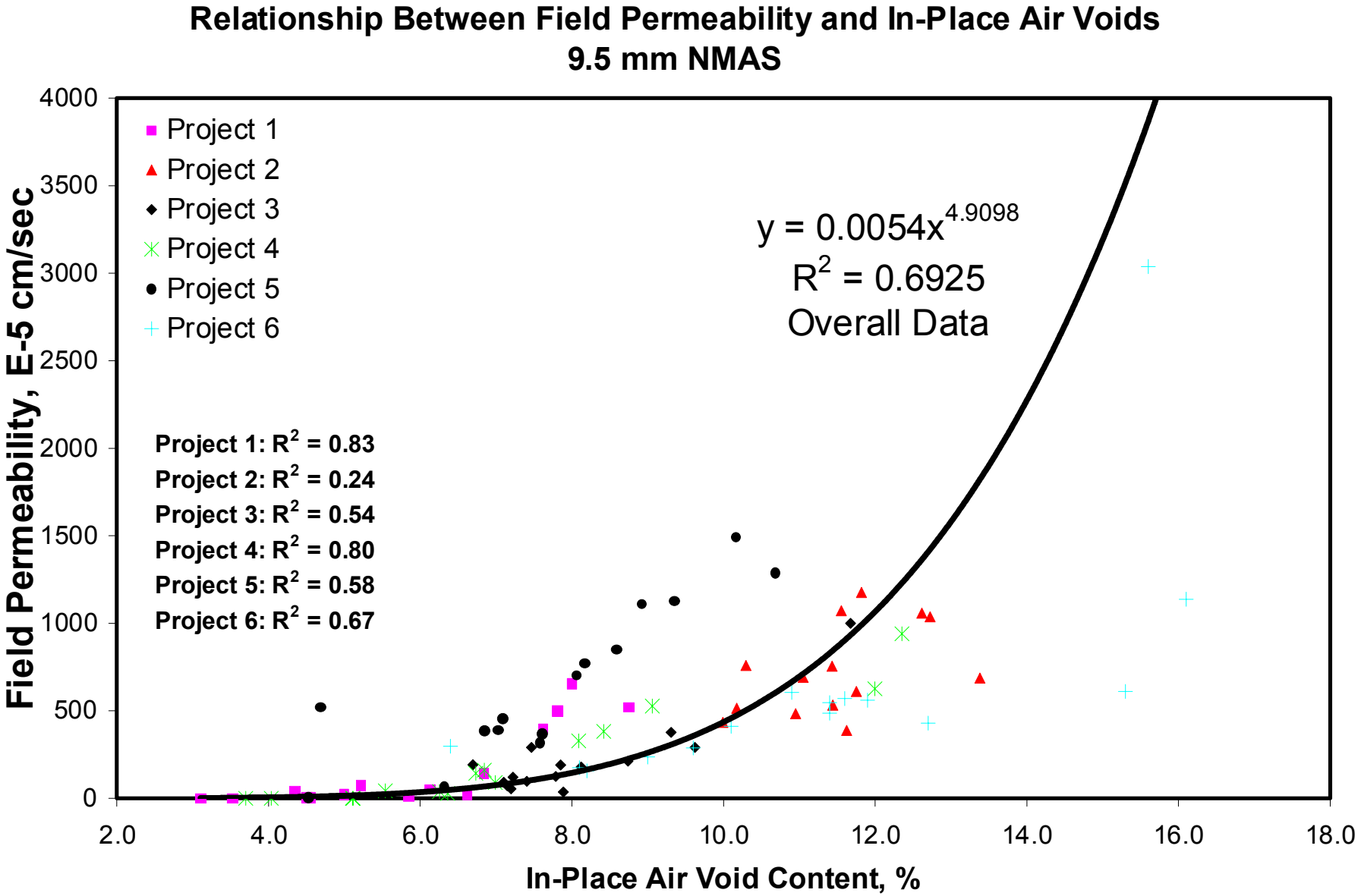
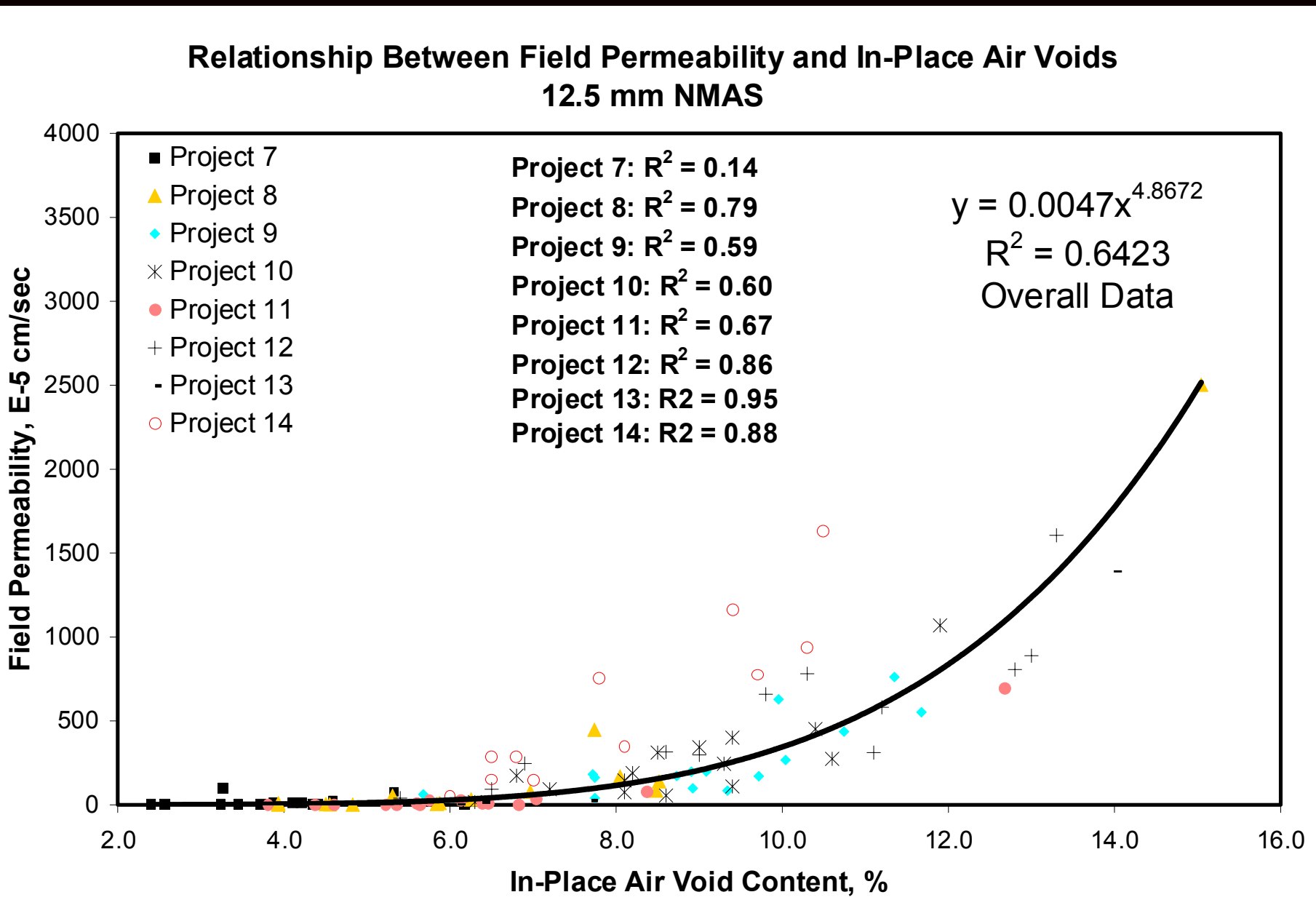
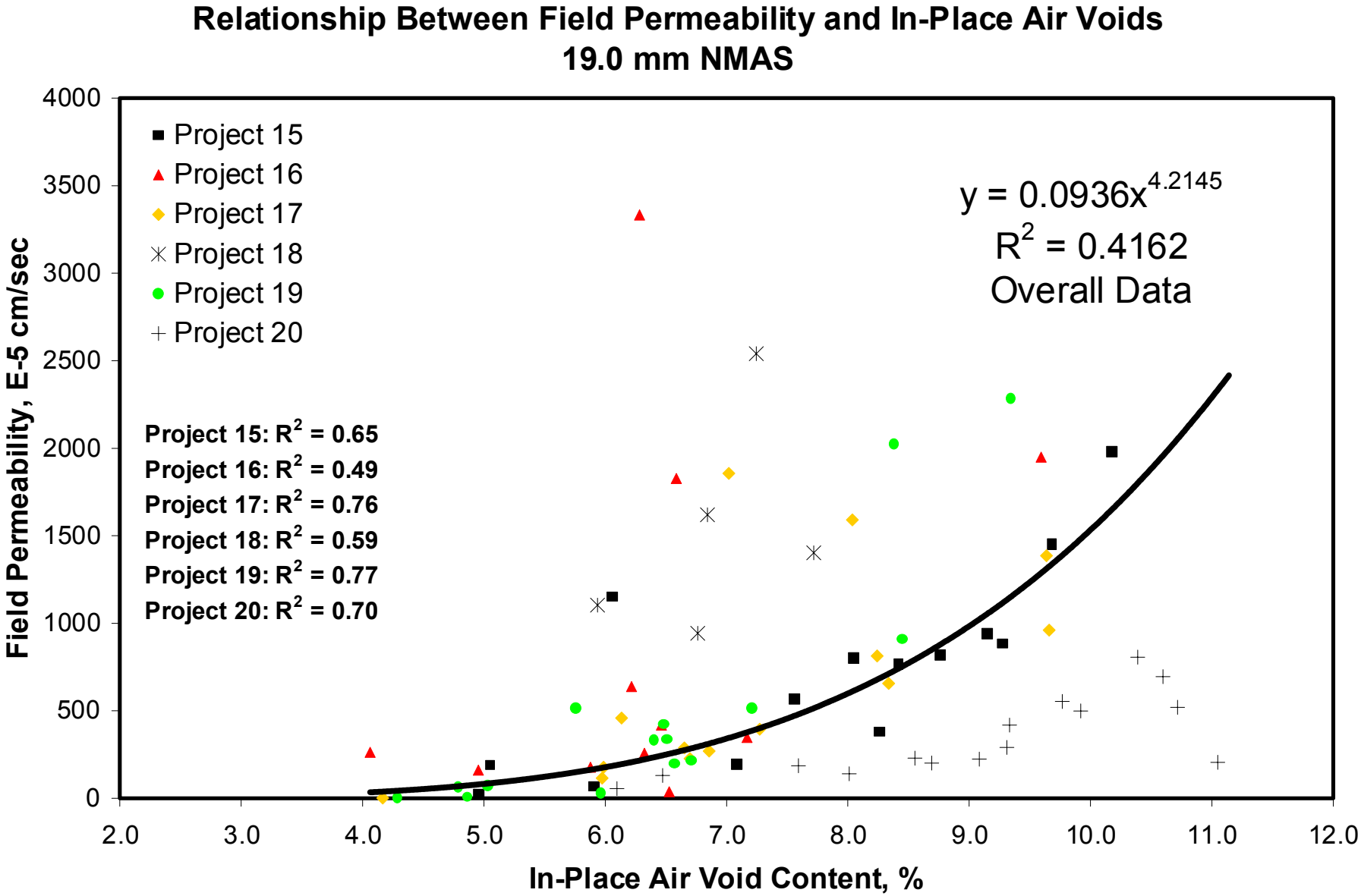
ROCKS

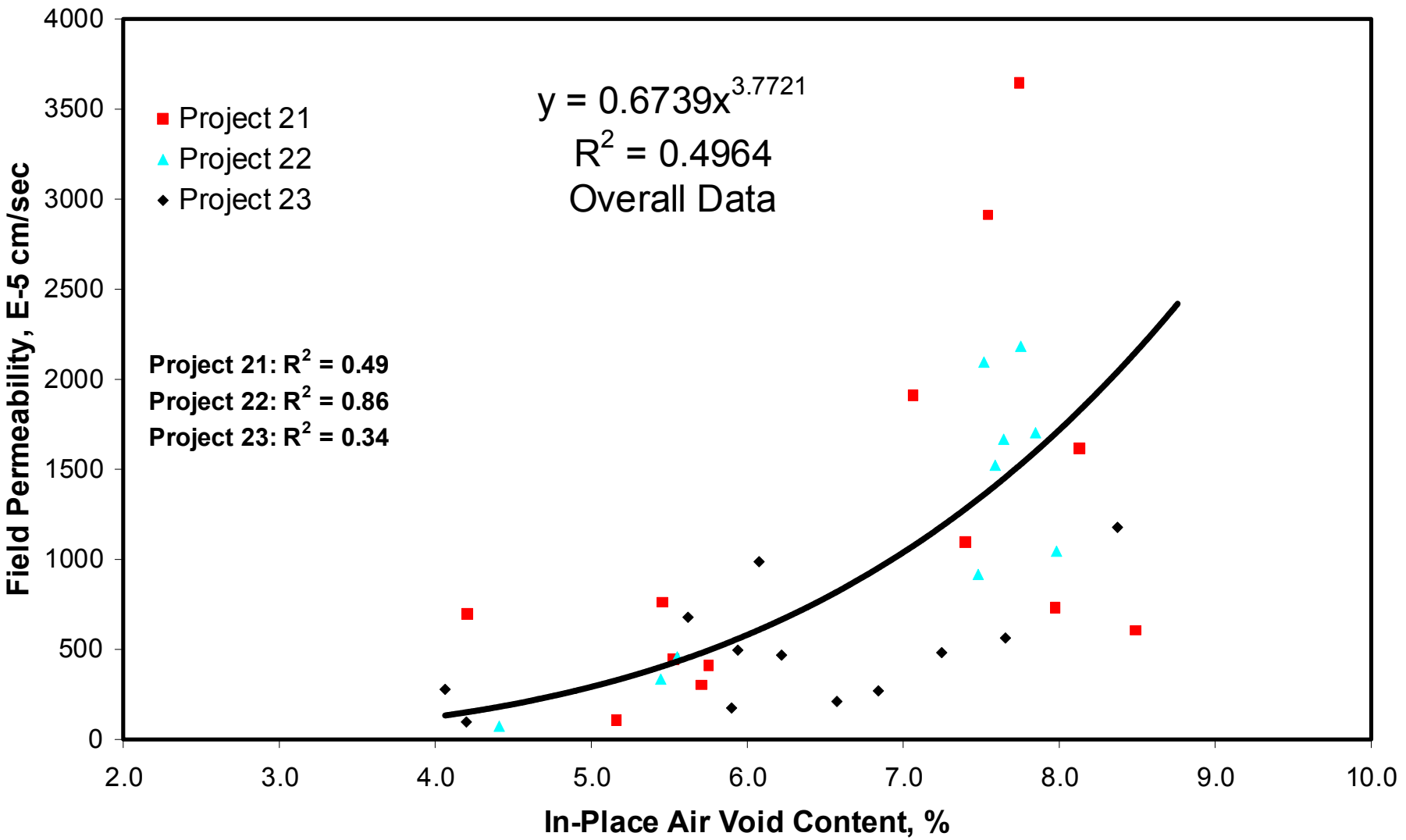
Factors Affecting Permeability

- Pavement Density
- NMAS
- Gradation Shape
- Lift Thickness
- Construction Equipment?


Relationship Between Field Permeability and In-Place Air Voids
9.5 mm NMAS
Field Permeability, E-5 cm/sec
In-Place Air Void Content, %
Project 1
Project 2
Project 3
Project 4
Project 5
Project 6
y = 0.0054x^4.9098
R2 = 0.6925
Overall Data
Project 1: R2 = 0.83
Project 2: R2 = 0.24
Project 3: R2 = 0.54
Project 4: R2 = 0.80
Project 5: R2 = 0.58
Project 6: R2 = 0.67
4000
3500
3000
2500
2000
1500
1000
500
0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0


Relationship Between Field Permeability and In-Place Air Voids
12.5 mm NMAS
Field Permeability, E-5 cm/sec
In-Place Air Void Content, %
Project 7
Project 8
Project 9
Project 10
Project 11
Project 12
Project 13
Project 14
Project 7: R2 = 0.14
Project 8: R2 = 0.79
Project 9: R2 = 0.59
Project 10: R2 = 0.60
Project 11: R2 = 0.67
Project 12: R2 = 0.86
Project 13: R2 = 0.95
Project 14: R2 = 0.88
y = 0.0047x4.8672
R2 = 0.6423
Overall Data
4000
3500
3000
2500
2000
1500
1000
500
0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0

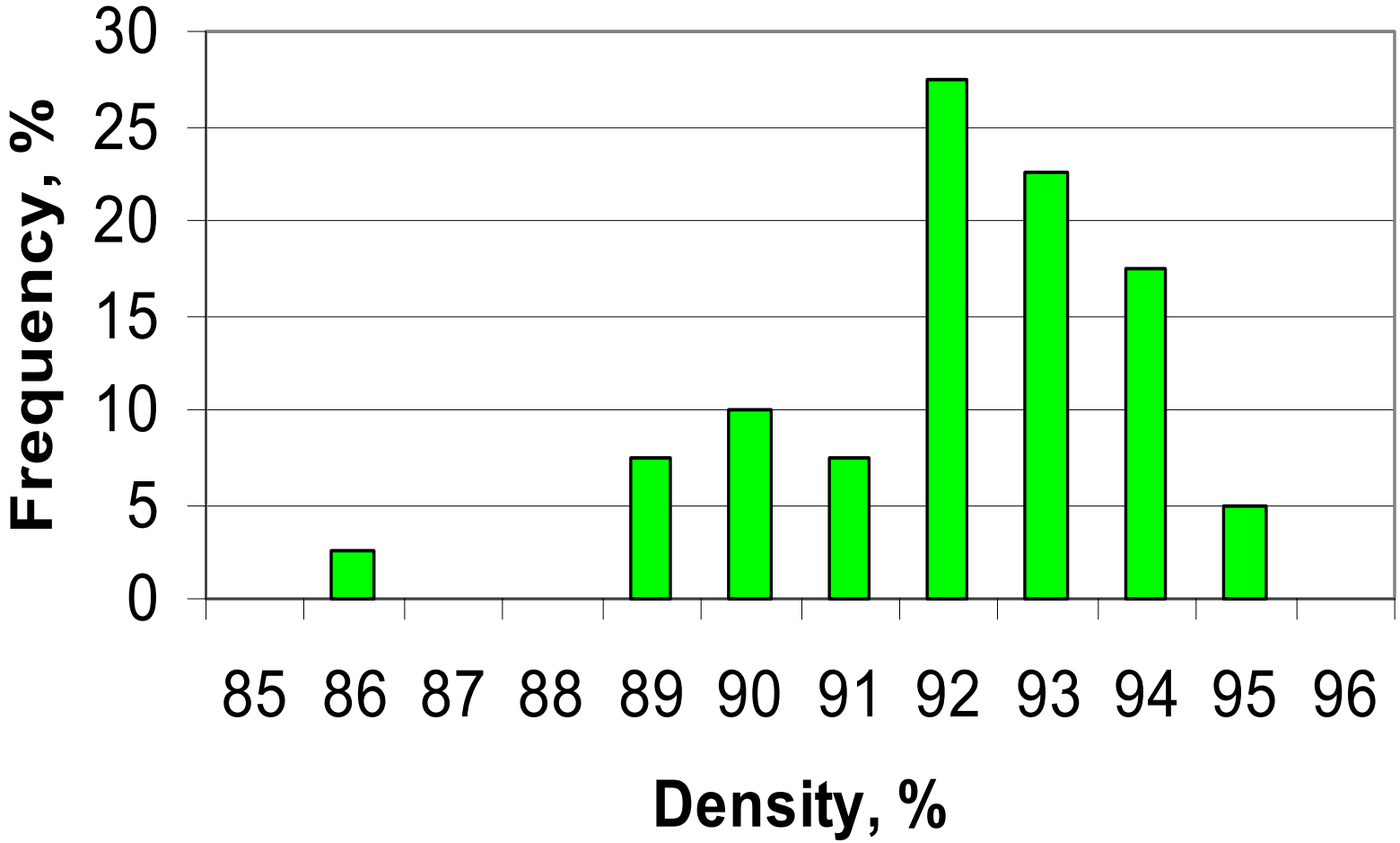

Relationship Between Field Permeability and In-Place Air Voids
19.0 mm NMAS
Field Permeability, E-5 cm/sec
In-Place Air Void Content, %
Project 15
Project 16
Project 17
Project 18
Project 19
Project 20
y = 0.0936x^4.2145
R^2 = 0.4162
Overall Data
Project 15: R^2 = 0.65
Project 16: R^2 = 0.49
Project 17: R^2 = 0.76
Project 18: R^2 = 0.59
Project 19: R^2 = 0.77
Project 20: R^2 = 0.70
4000
3500
3000
2500
2000
1500
1000
500
0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0

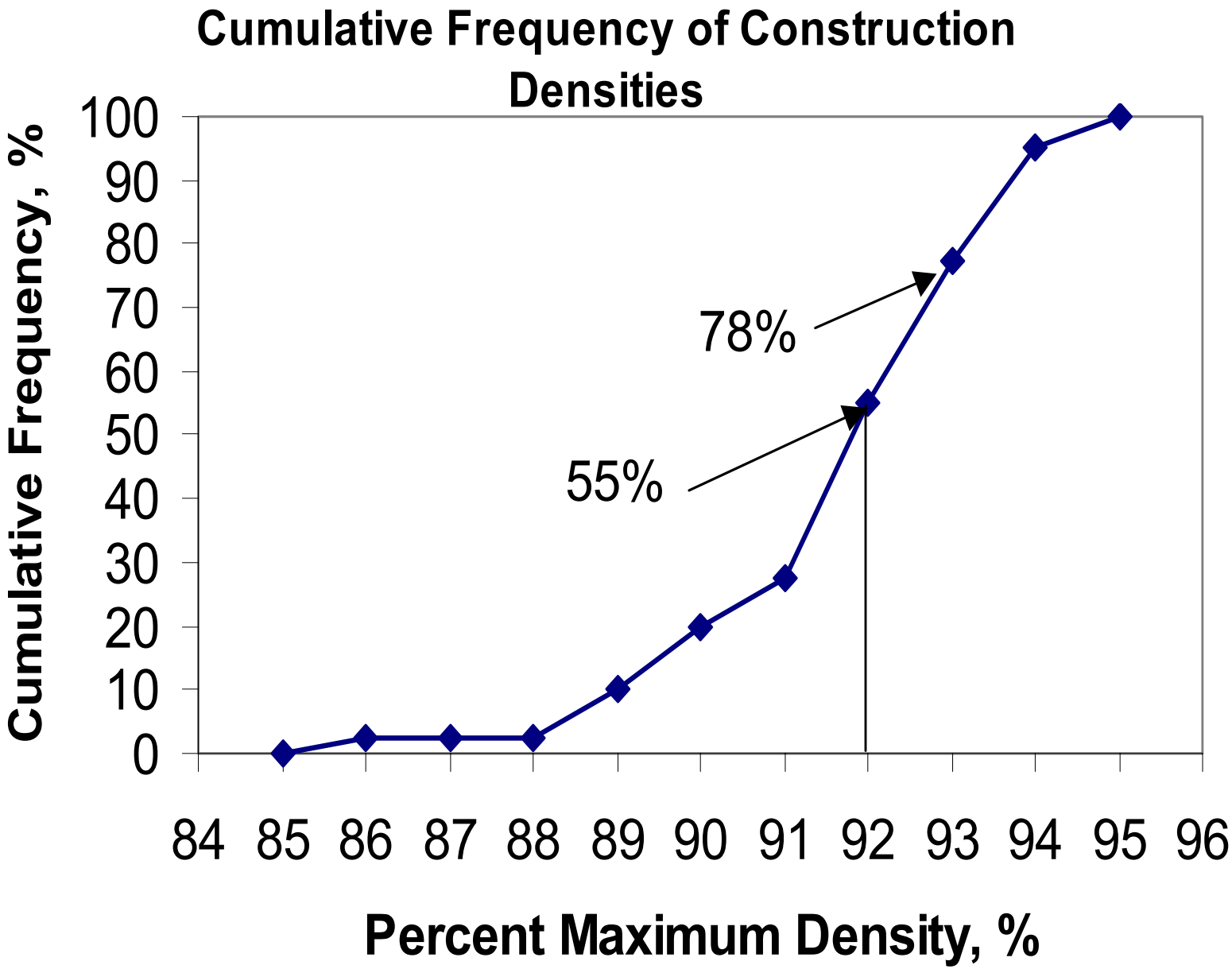

Relationship Between Field Permeability and In-Place Air Voids
25.0 mm NMAS
Field Permeability, E-5 cm/sec
In-Place Air Void Content, %
Project 21
Project 22
Project 23
y = 0.6739x^3.7721
R2 = 0.4964
Overall Data
Project 21: R2 = 0.49
Project 22: R2 = 0.86
Project 23: R2 = 0.34
0
500
1000
1500
2000
2500
3000
3500
4000
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0

Critical Density Values

- 9.5 and 12.5 mm NMAS ~ 7.5 – 8.0 %
- 19.0 mm NMAS ~ 6.0 – 6.5 %
- 25.0 mm NMAS ~ 5.5 – 6.0 %

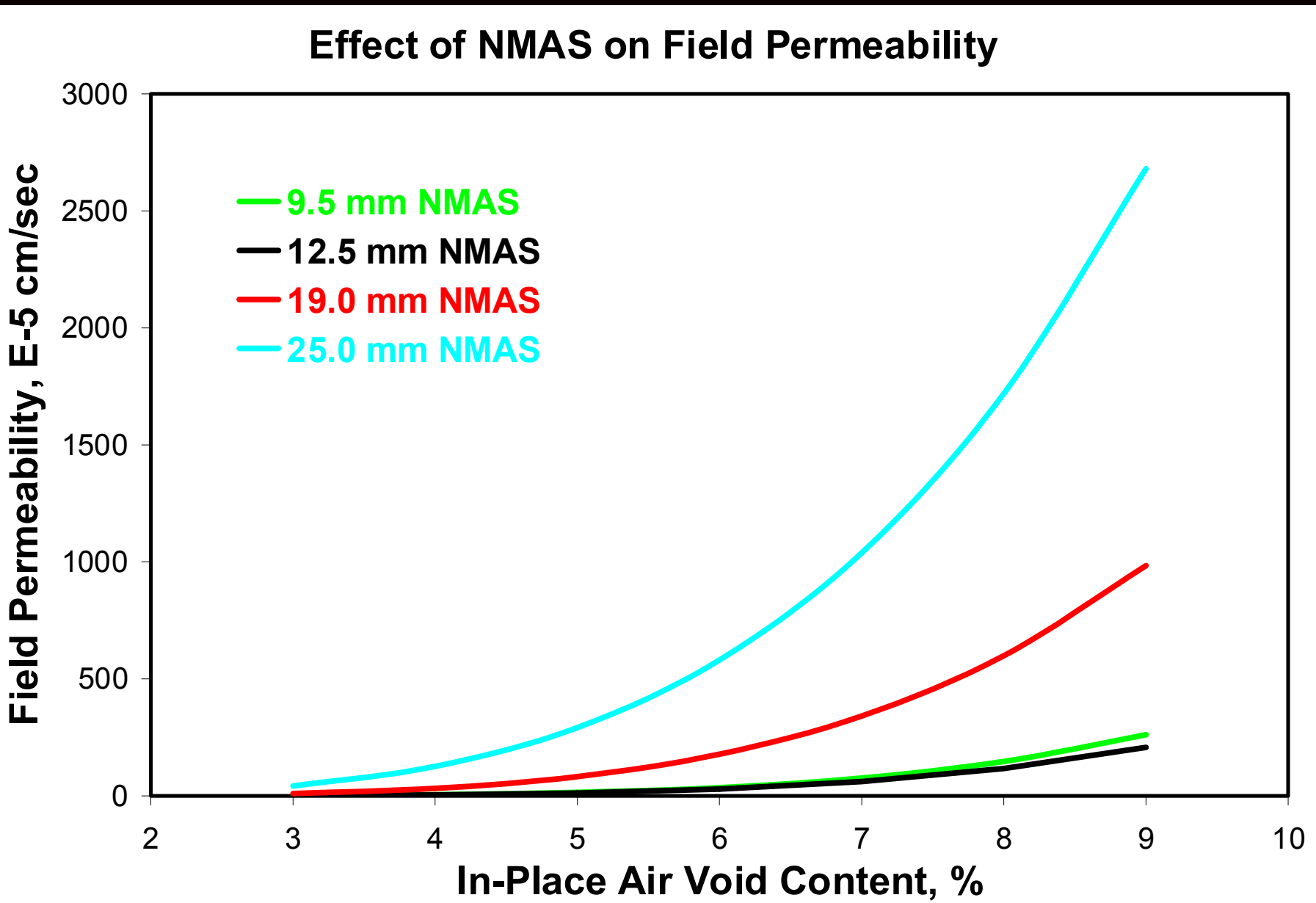
Frequency Distribution of Construction Densities

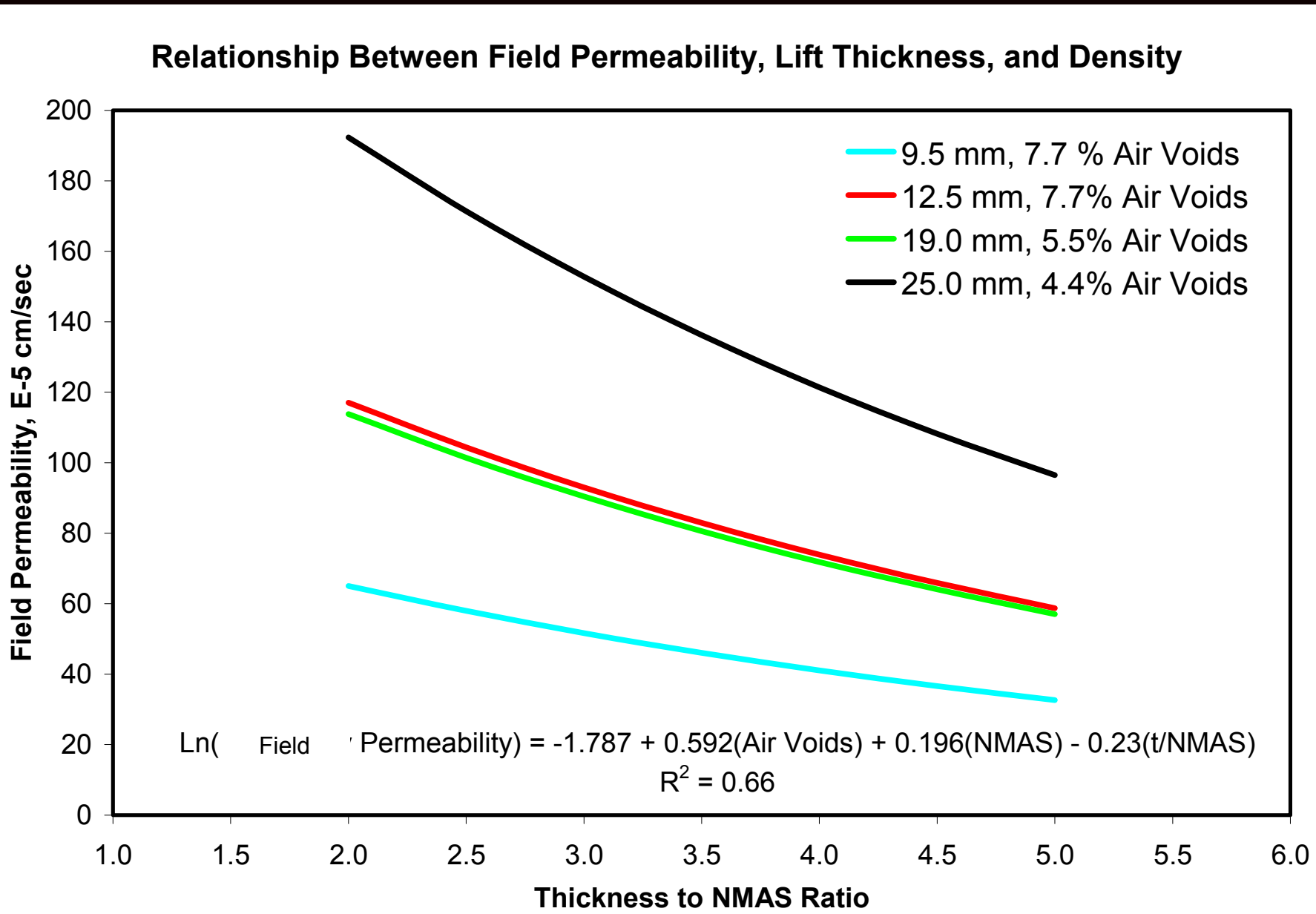



Cumulative Frequency of Construction Densities
Cumulative Frequency, %
100
90
80
70
60
50
40
30
20
10
0
78%
55%
84
85
86
87
88
89
90
91
92
93
94
95
96
Percent Maximum Density, %

Construction Densities

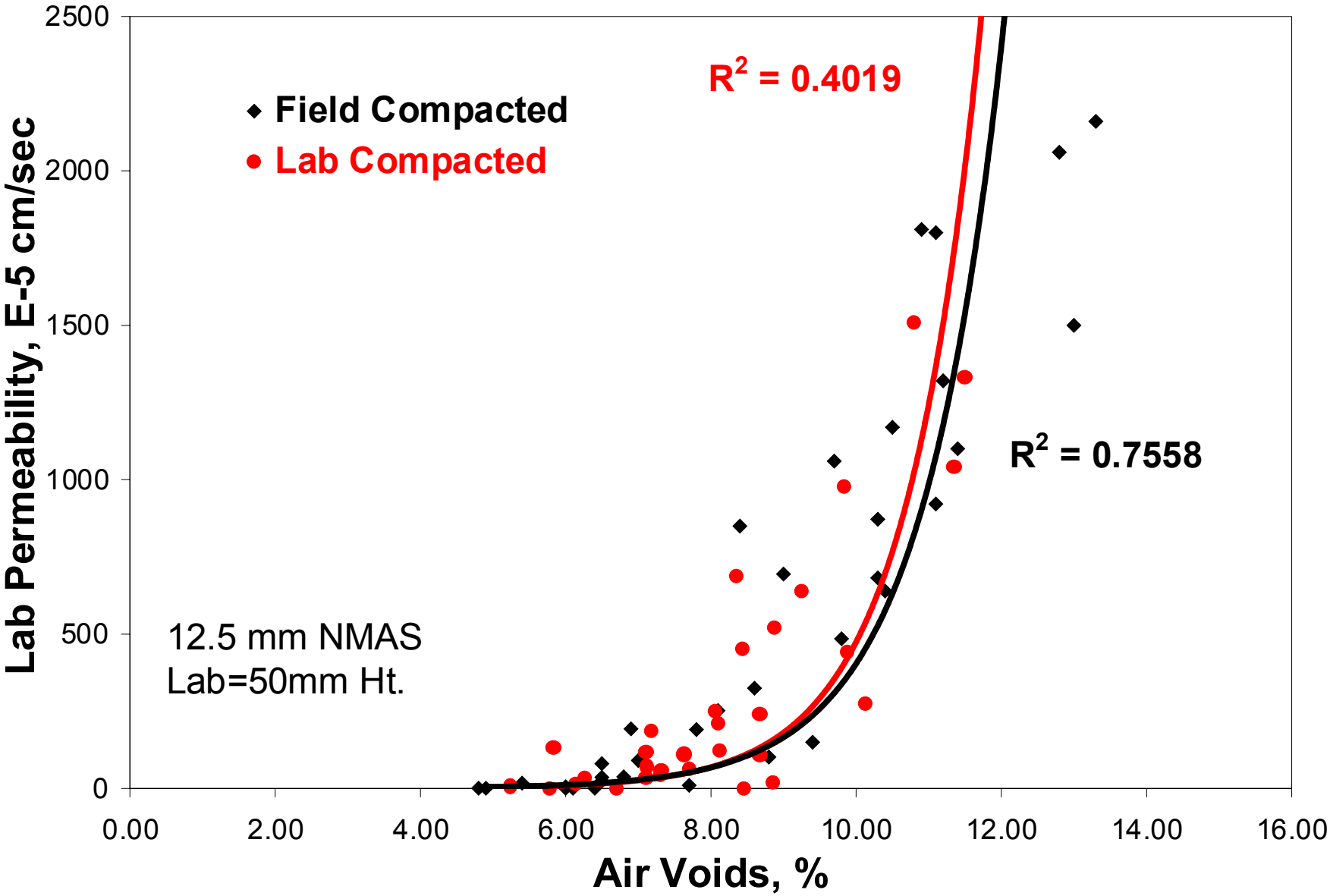
- 55% of (22 of 40) projects construction densities were less than 92%
- 78% of (31 of 40) projects construction densities were less than 93%
- Construction densities tended to be grouped by state
- May be related to state's specifications

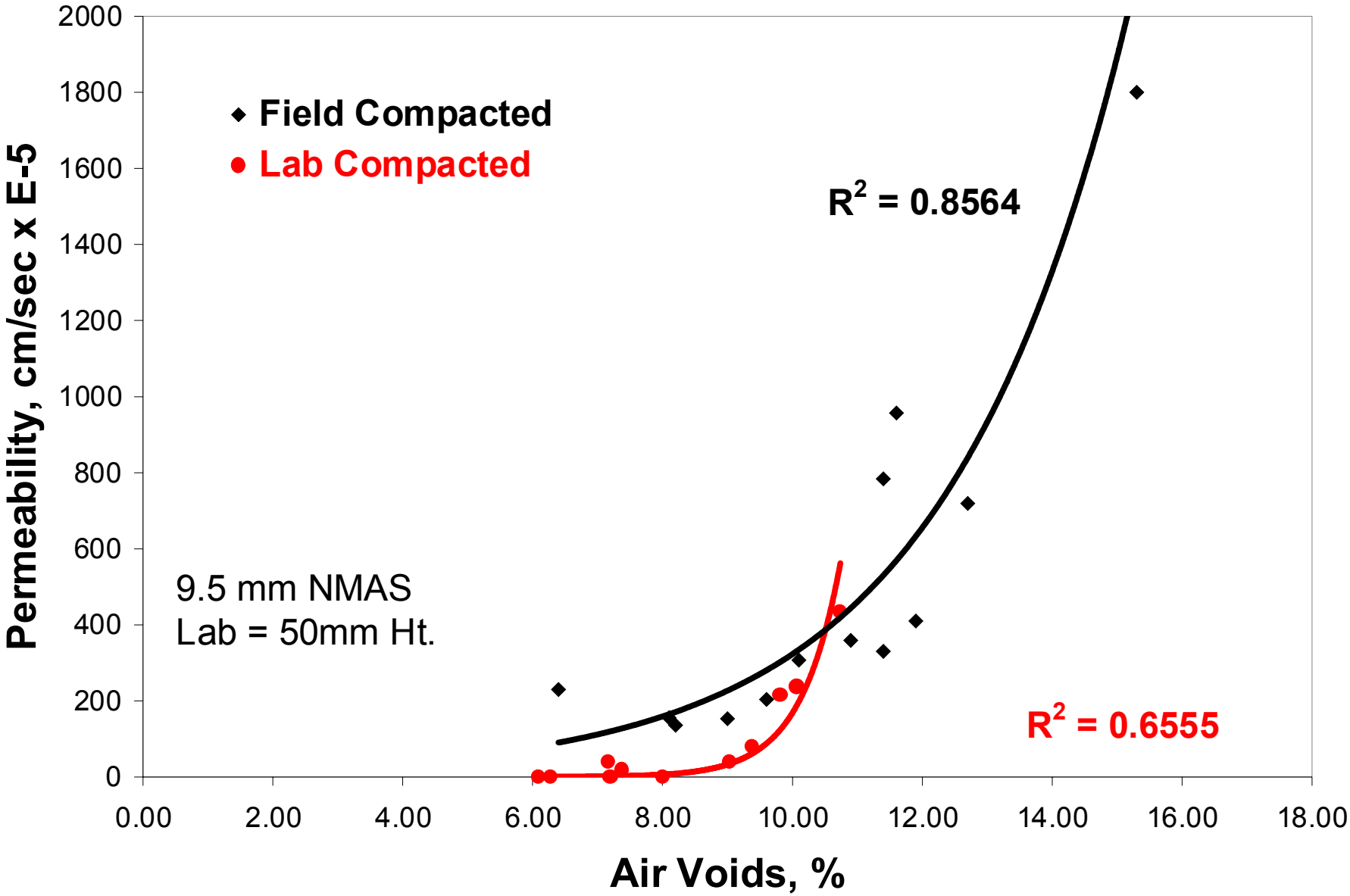

Effect of NMAS on Field Permeability
Field Permeability, E-5 cm/sec
3000
2500
2000
1500
1000
500
0
9.5 mm NMAS
12.5 mm NMAS
19.0 mm NMAS
25.0 mm NMAS
2
3
4
5
6
7
8
9
10
In-Place Air Void Content, %


Relationship Between Field Permeability, Lift Thickness, and Density
Field Permeability, E-5 cm/sec
200
180
160
140
120
100
80
60
40
20
0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
Thickness to NMAS Ratio
9.5 mm, 7.7 % Air Voids
12.5 mm, 7.7% Air Voids
19.0 mm, 5.5% Air Voids
25.0 mm, 4.4% Air Voids
Ln(Field Permeability) = -1.787 + 0.592(Air Voids) + 0.196(NMAS) - 0.23(t/NMAS)
R2 = 0.66

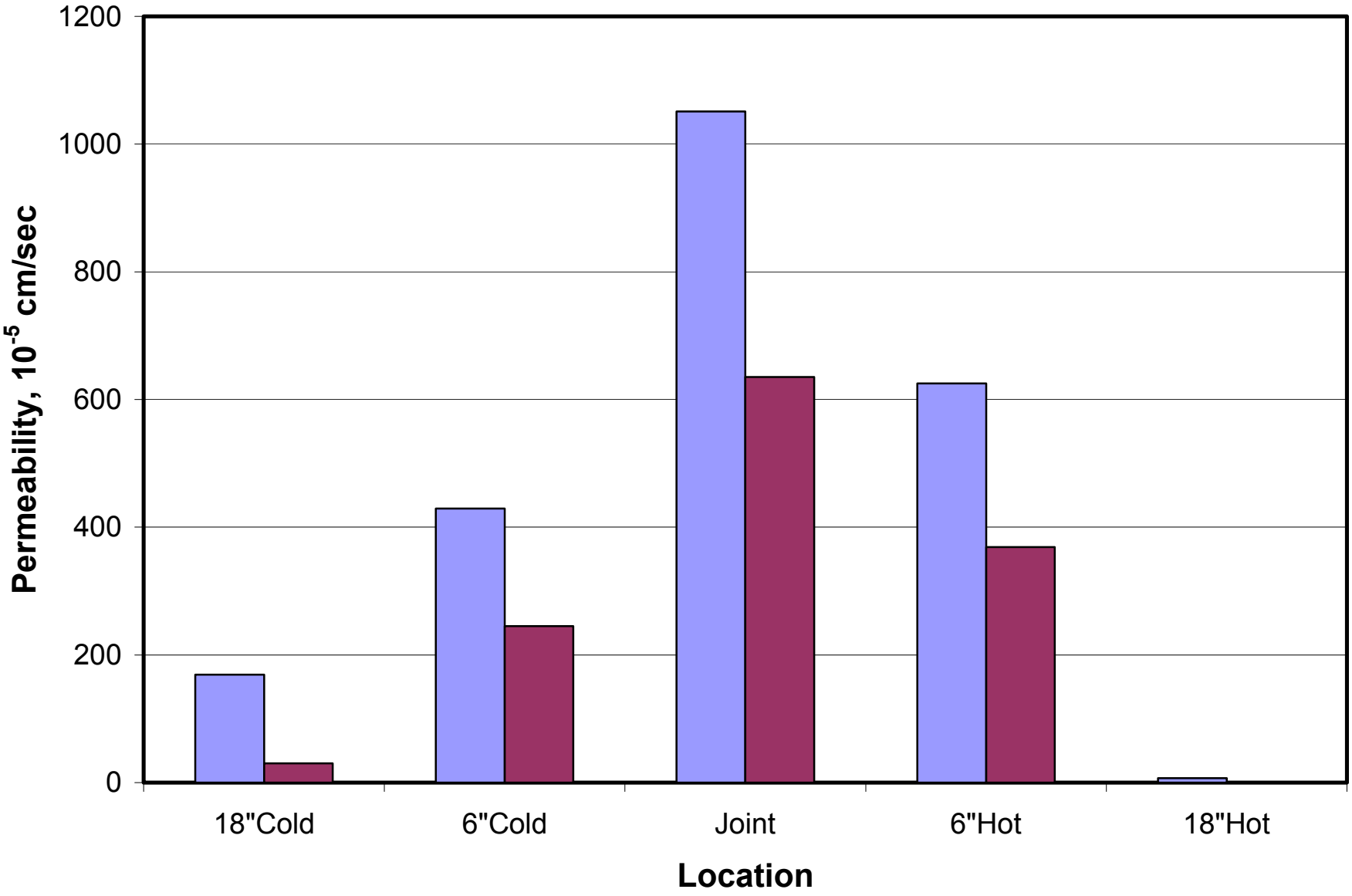
Is There a Tool to Predict Permeability at QC?

- Water Absorption from T166?
  - Defining permeable voids?

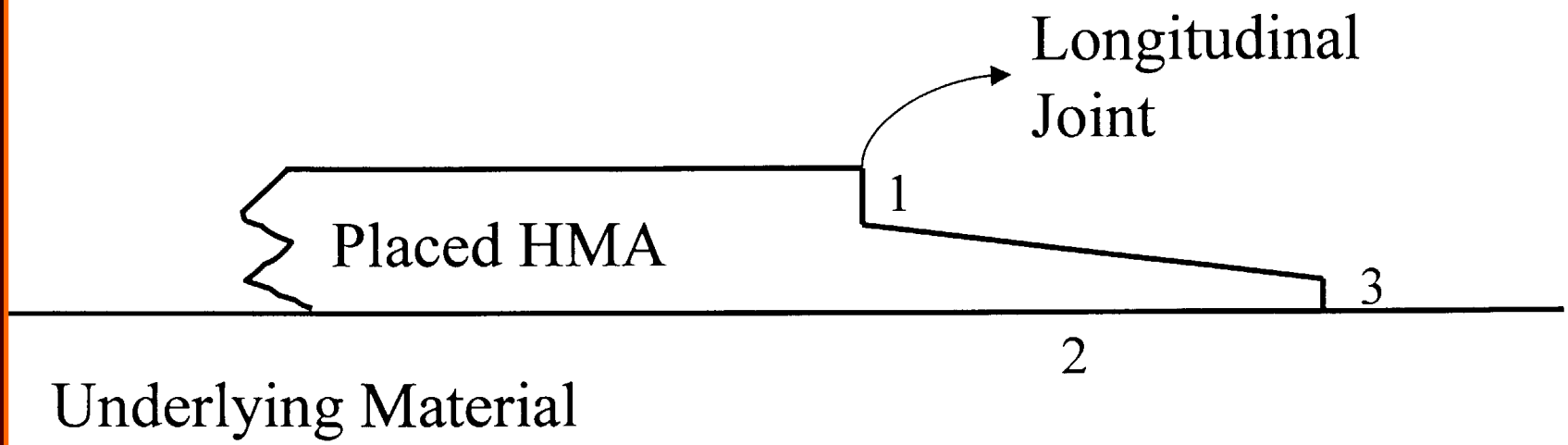

Lab Permeability, E-5 cm/sec
2500
2000
1500
1000
500
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
Air Voids, %
Field Compacted
Lab Compacted
R2 = 0.4019
R2 = 0.7558
12.5 mm NMAS
Lab=50mm Ht.


Permeability, cm/sec x E-5
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
Air Voids, %
Field Compacted
Lab Compacted
R2 = 0.8564
R2 = 0.6555
9.5 mm NMAS
Lab = 50mm Ht.

Longitudinal Joints


1200
1000
800
600
400
200
0
Permeability, 10-5 cm/sec
18"Cold
6"Cold
Joint
6"Hot
18"Hot
Location

Notched Wedge Joint

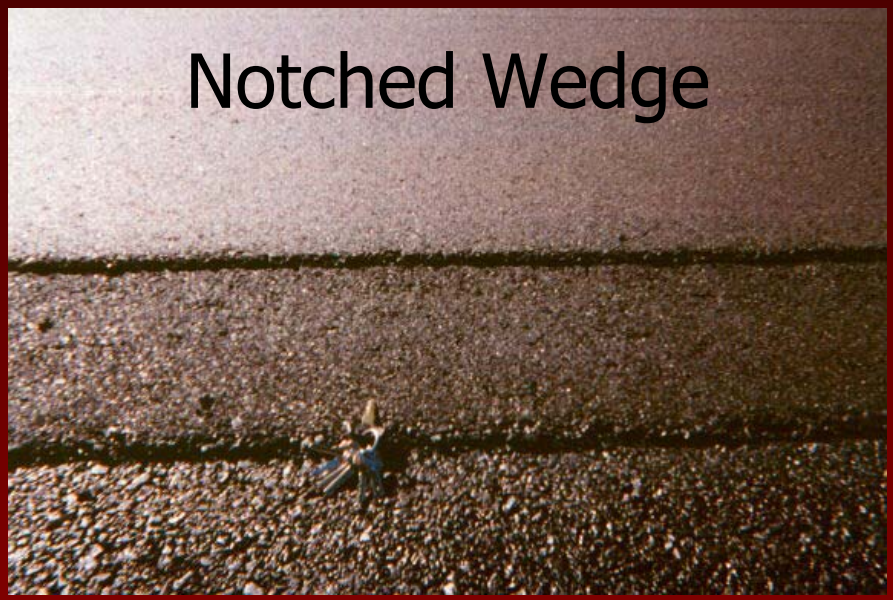


(1) Vertical Notch Depth = 0.5 to 0.75 inches

(2) Length of Wedge = 12 inches

(3) Wedge Thickness at Edge = Nominal Maximum Aggregate Size of Mix

Notched Wedge Joint



Summary

- There are a number of construction related issues that can increase the potential for moisture damage.
  - Minimize Segregation
  - Minimize Permeability
- There is a relationship between density and permeability.
- NMAS, gradation shape, and lift thickness affect this relationship.

Summary

- During Mix Design
  - Compact samples to design lift thickness
  - Vary air voids to anticipated field values
  - Determine Permeability
- Longitudinal Joints
  - Research Needs to be conducted Using Permeability as a Quality Indicator